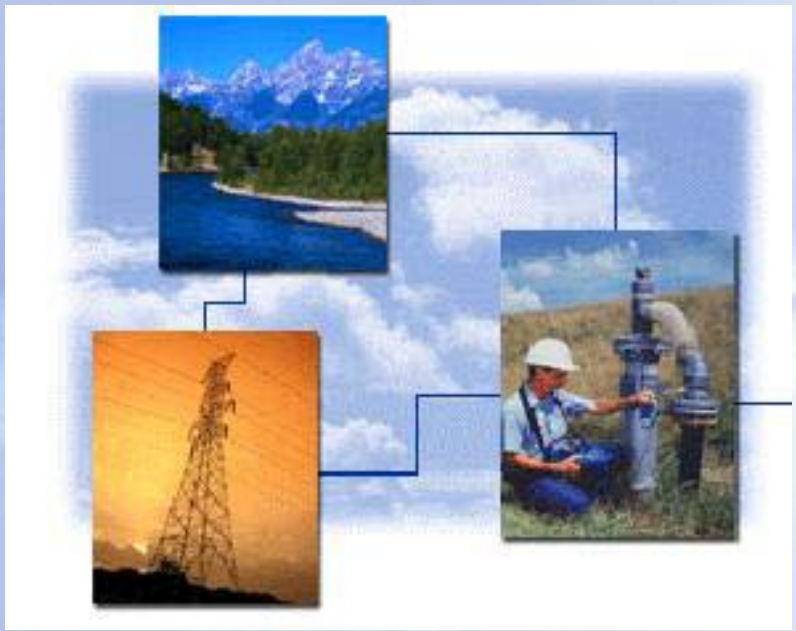
Landfill Gas Energy Opportunities in the U.S. Virgin Islands



Chris Voell, Program Manager

U.S. Environmental Protection Agency

Landfill Methane Outreach Program (LMOP)

Why Does EPA Care About LFG?

LANDFILL METHANE OUTREACH PROGRAM

- Methane is a potent heat-trapping gas.
- Landfills are the largest human-made source of methane in the US.
- There are many cost effective options for reducing methane emissions while generating energy.
- Projects reduce local air pollution.
- Projects create jobs, revenues, and cost savings.

EPA's Landfill Methane Outreach Program

- Established in 1994
- Voluntary program that creates alliances among states, energy users/providers, the landfill gas industry, and communities

Mission: To reduce methane emissions by lowering barriers and promoting the development of cost-effective and environmentally beneficial landfill gas energy (LFGE) projects.

Landfill Gas 101

- Landfill gas (LFG) is a by-product of the decomposition of municipal solid waste (MSW).
- LFG:
  - ~ 50% methane (CH_4).
  - ~ 50% carbon dioxide (CO_2).
  - <1% non-methane organic compounds (NMOCs).
- For every 1 million tons of MSW:
  - ~ 1.0 MW of electricity
  - ~ 550,000 cubic feet per day of landfill gas.
- If uncontrolled, LFG contributes to smog and global warming, and may cause health and safety concerns.

LFGE Projects Provide Dual Benefits

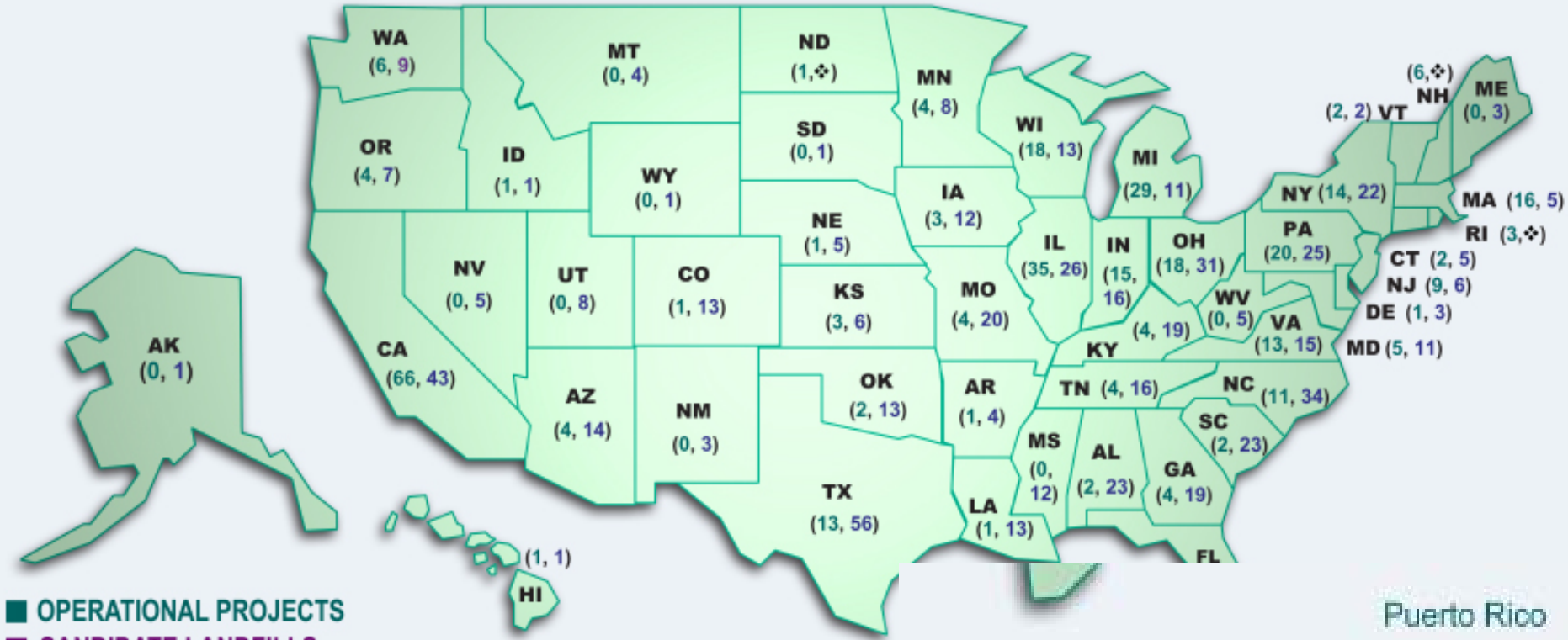
- Destroys methane and other organic compounds in LFG
  - Each 1 MW of generation = planting ~12,000 acres of trees per year, removing the emissions of ~8,800 cars per year, or preventing the use of ~93,000 barrels of oil per year
- Offsets use of nonrenewable resources (coal, oil, gas) reducing emissions of:
  - SO_2 contributes to acid rain
  - NO_x contributes to ozone formation and smog
  - PM is a respiratory health concern
  - CO_2 is a global warming gas

State of the National LFGE Industry (as of Sept. 2003)

- 359 operational projects in 40 states supplying:
  - 8 billion kilowatt hours of electricity per year, and
  - 75 billion cubic feet per year of landfill gas to direct use applications
- At least 100 under construction and planned projects
- Currently over 600 candidate landfills and a total potential of over 1,500 MW or

Status of Operational LFGE Projects and Candidate Landfills

LANDFILL METHANE OUTREACH PROGRAM



■ OPERATIONAL PROJECTS
■ CANDIDATE LANDFILLS

Nationwide Summary

359 Operational Projects

>600 Candidate Landfills have 17 MMTCE Potential

These data are from LMOP's database as of N

❖LMOP does not have any information on candi in this state.

U.S. Virgin Islands

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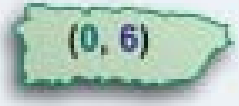
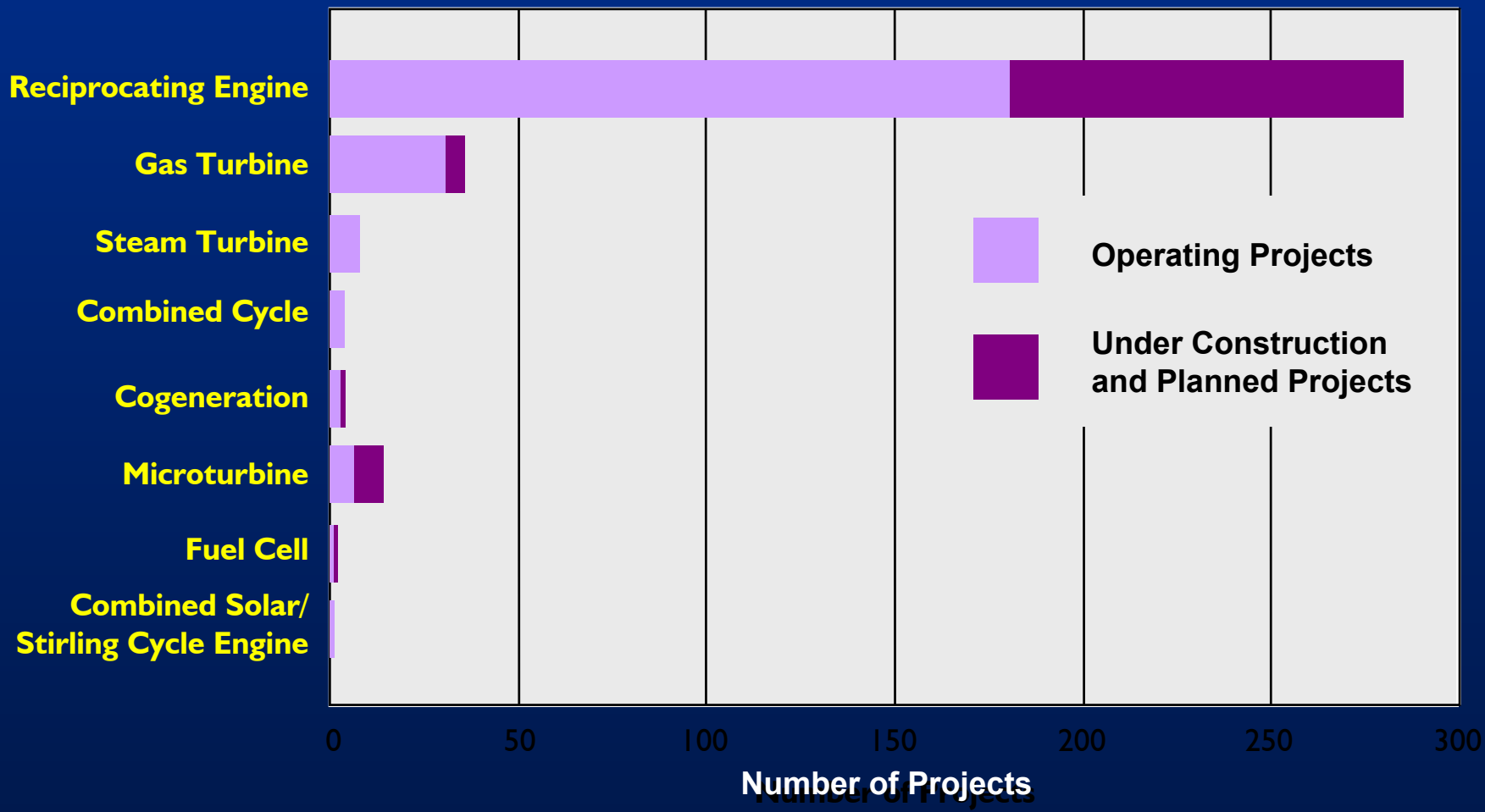
Puerto Rico

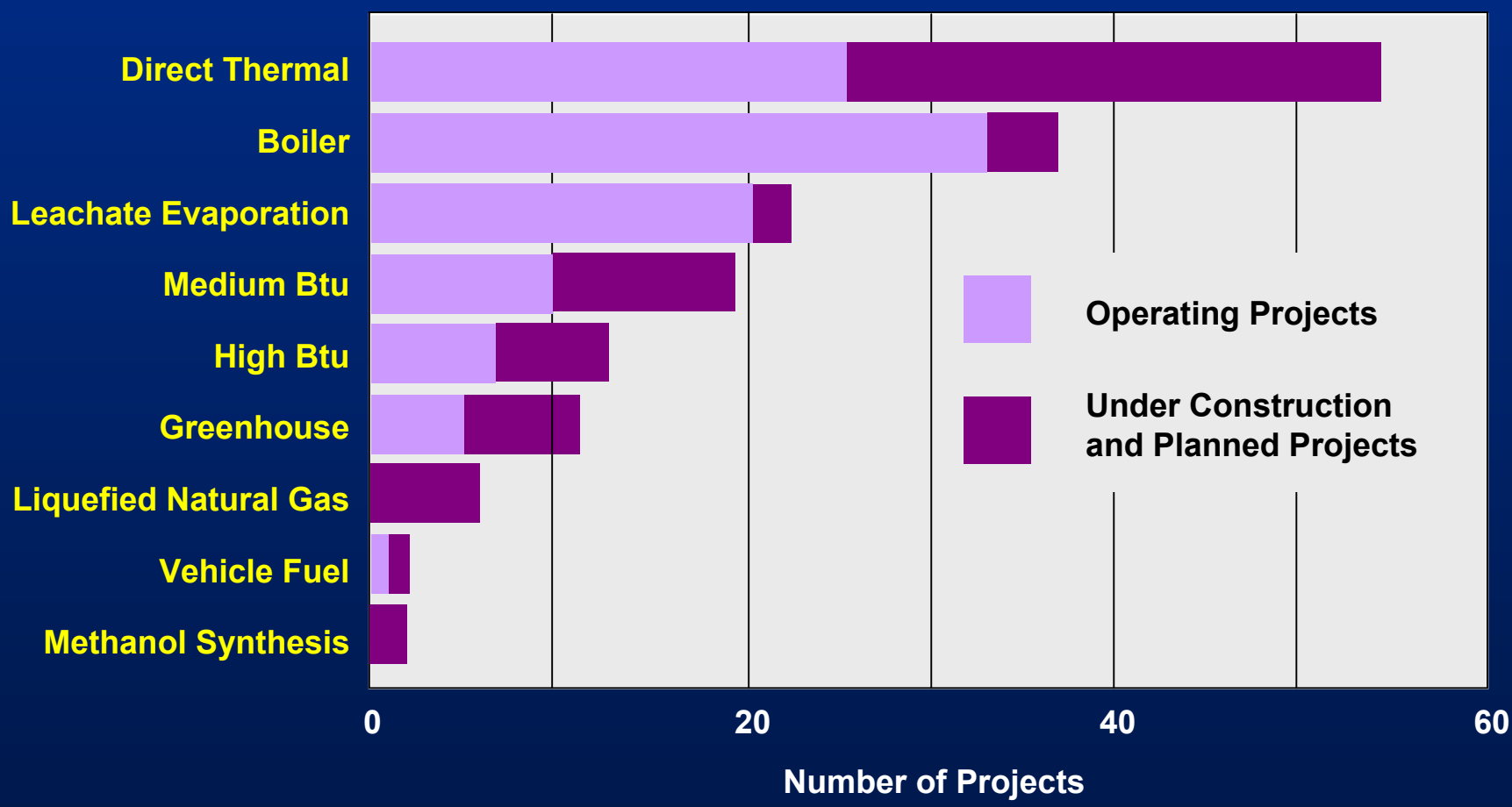


PR

Technology Trends
Electricity Projects



Technology Trends
Direct Use

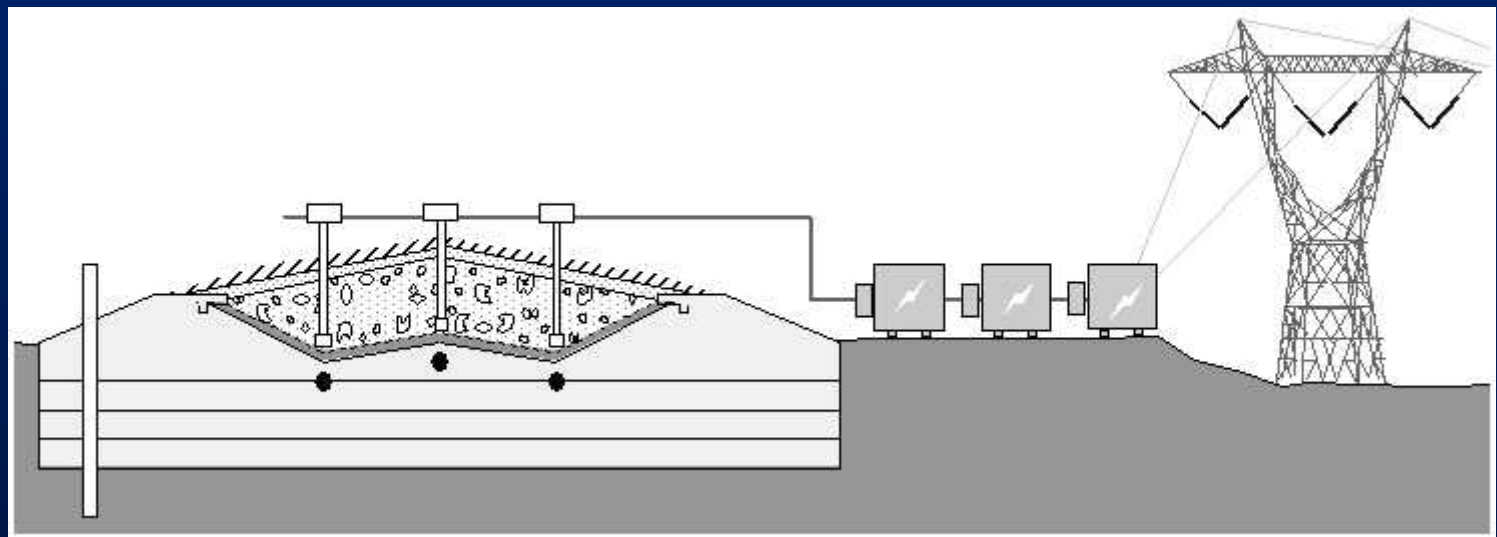


Environmental Benefits from Current LFGE Projects Nationwide
(as of Sept. 2003)

- Estimated **Annual** Benefits:
  - Planting **18,000,000 acres of forest**,
  - Preventing the use of **140,000,000 barrels of oil**,
  - Removing emissions equivalent to **13,000,000 cars**, or
  - Offsetting the use of **295,000 railcars of coal**.

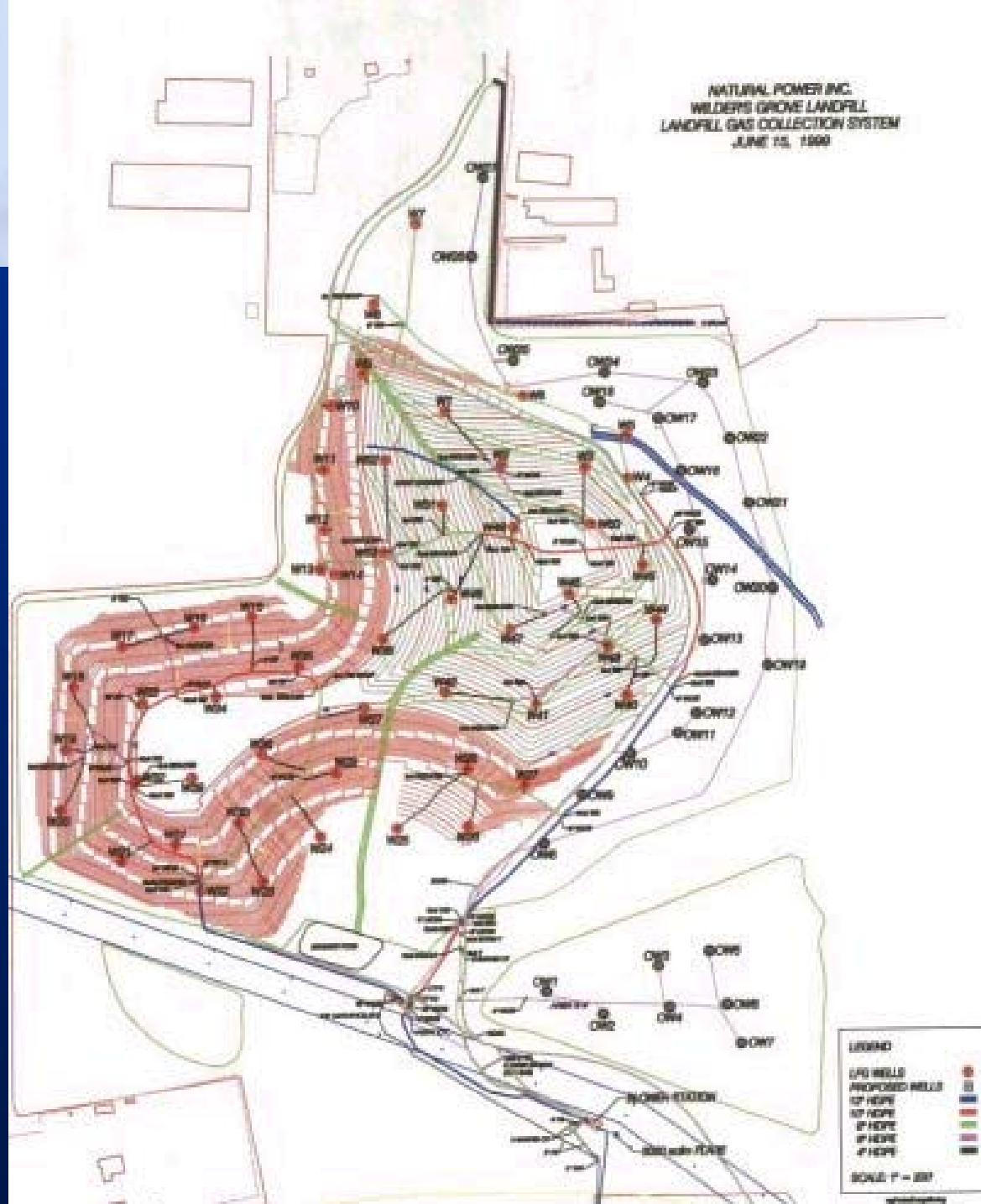
Gas Collection and Treatment

- Wellfield
- Blower/Compressor
- Flare
- Gas Processing



Gas Collection and Treatment

Wellfield Schematic



Gas Compression and Treatment

Compressor

300 HP electric motor driven oil-flooded screw compressor

2 Stage fuel gas booster

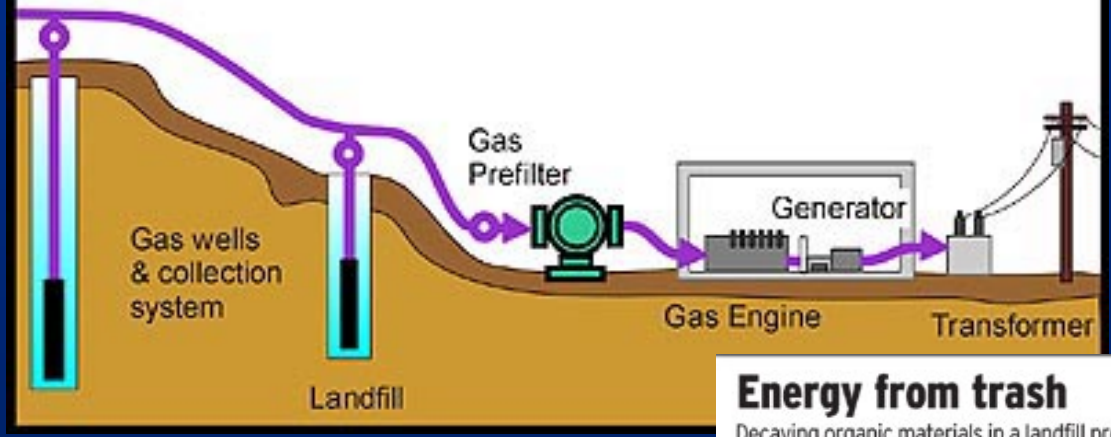
Coalescing Filters

400 HP electric motor driven screw compressors

Freon Chiller Compressor

Short Mountain Landfill

A group of wells pump methane through a filtering system to 1,150-horsepower/820-KW engines. The engines run electric generators which provide power to a transformer connected to Emerald's distribution system that serves Goshen, Creswell and Pleasant Hill.



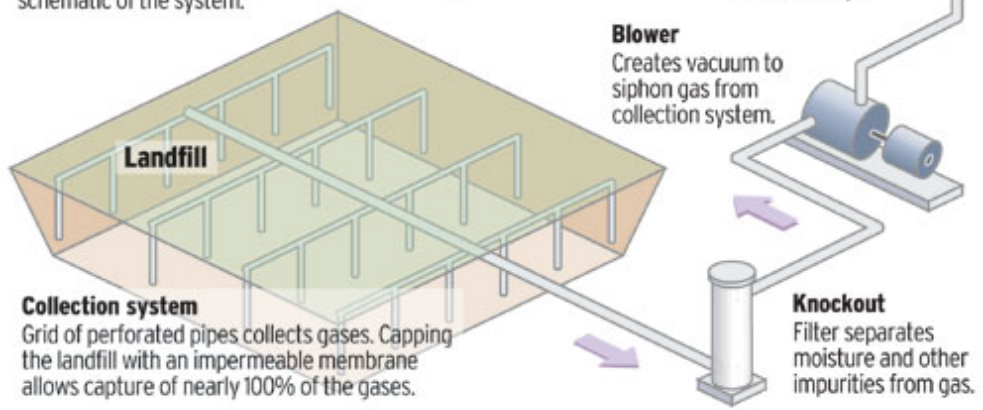
LANDFILL METHANE OUTREACH PROGRAM

Energy from trash

Decaying organic materials in a landfill produce LFG (landfill gas) composed of about 55% methane and 45% carbon dioxide. This process can go on for many decades in large landfills. Springfield has installed a gas recovery system at the landfill, currently burning off the gas to reduce air pollution (methane is a "greenhouse gas"). Future plans may include installing a gas turbine to generate electricity, thus providing usable energy from the landfill. Here's a schematic of the system:

Flare
Burning off methane is the simplest solution. In the future this energy may be used for production of electricity.

Blower
Creates vacuum to siphon gas from collection system.



Collection system
Grid of perforated pipes collects gases. Capping the landfill with an impermeable membrane allows capture of nearly 100% of the gases.

Knockout
Filter separates moisture and other impurities from gas.

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY; LANDFILL METHANE OUTREACH PROGRAM

JEFF HARPER / NEWS-LEADER

Possible Uses

- Direct Use
  - Boilers
  - Direct thermal applications
  - Innovative applications
    - Greenhouses, infrared heaters, pottery kilns, leachate evaporation
- Combined Heat and Power
  - Industrial
  - Community-based
- Electricity Production
  - Internal Combustion Engines
  - Turbines
  - Microturbines
  - Emerging Technologies
    - Fuel Cell, Stirling Engine, Organic Rankine Cycle Engine
- Alternate Fuels
  - High-Btu Upgrade
  - Medium-Btu Injection
  - LNG/CNG

Direct Use

- Gas piped to a nearby customer for use
- 100+ projects in the US
- Pipeline length range growing
  - less than 1/2 mile to 21 miles
- Gas can be used on-site

Advantages/Disadvantages

- Advantages
  - Most cost-effective
  - Simple technology
  - Minimal processing requirements
  - Most cost effective
- Disadvantages
  - Requires locating a customer within close proximity of the landfill
  - Right of way permits
  - Local terrain not conducive to pipeline installation

Costs

- $1.50 to $3.50 per MMBtu, depending on:
  - Pipeline length
  - Collection system in-place at landfill
- Other costs
  - Boiler retrofit
  - Operation and maintenance

Diversity of Project Types
Direct Use of LFG

- Direct-use projects are growing!
  - Boiler applications - replace natural gas, coal, fuel oil
  - Combined heat & power (CHP)
  - Direct thermal (dryers, kilns)
  - Natural gas pipeline injection
    - Medium and high-Btu
  - Greenhouse
  - Leachate evaporation
  - Vehicle fuel (LNG)
  - Artist studios
  - Hydroponics
  - Aquaculture (fish farming)

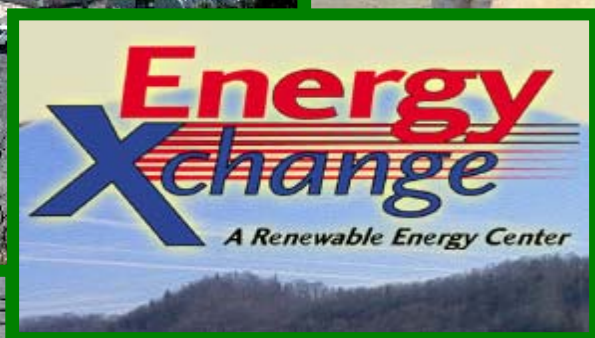
Greenhouse Burlington, NJ

Pottery Studio Sugar Grove, NC

LFG-fired Boiler Ft. Wayne, IN

EnergyXchange, NC
Engaging Communities

LANDFILL METHANE OUTREACH PROGRAM



Look Who's Using Landfill Gas

Direct Use Case Studies

- **NASA** (Greenbelt, MD) - LFG replaces natural gas in boiler-produce steam; saving $350K/year on fuel cost; no cost to the government; increases energy reliability; 5-mile pipeline.
- **Jersey Shore Steel** (Wayne, PA) - 1/2 mile pipeline; LFG used as a medium btu gas for reheating railroad rails to create a high quality angle iron; landfill provides approximately 600 cfm to the mill or 18,000,000 btu's per hour.
- **Cherokee Brick and Tile** (Macon, GA) - 1/2 mile pipeline; gas used in brick kilns
- **General Motors** (Ft. Wayne, IN) - 9-mile pipeline; LFG replaces fuel oil in boiler; produces steam to heat assembly plant and process equipment, and to drive turbines to produce chilled water and to pump water; savings of $750K/year.
- **Cargill** (Fargo, ND) - 1 mile pipeleine; LFG used in soybean processing operation

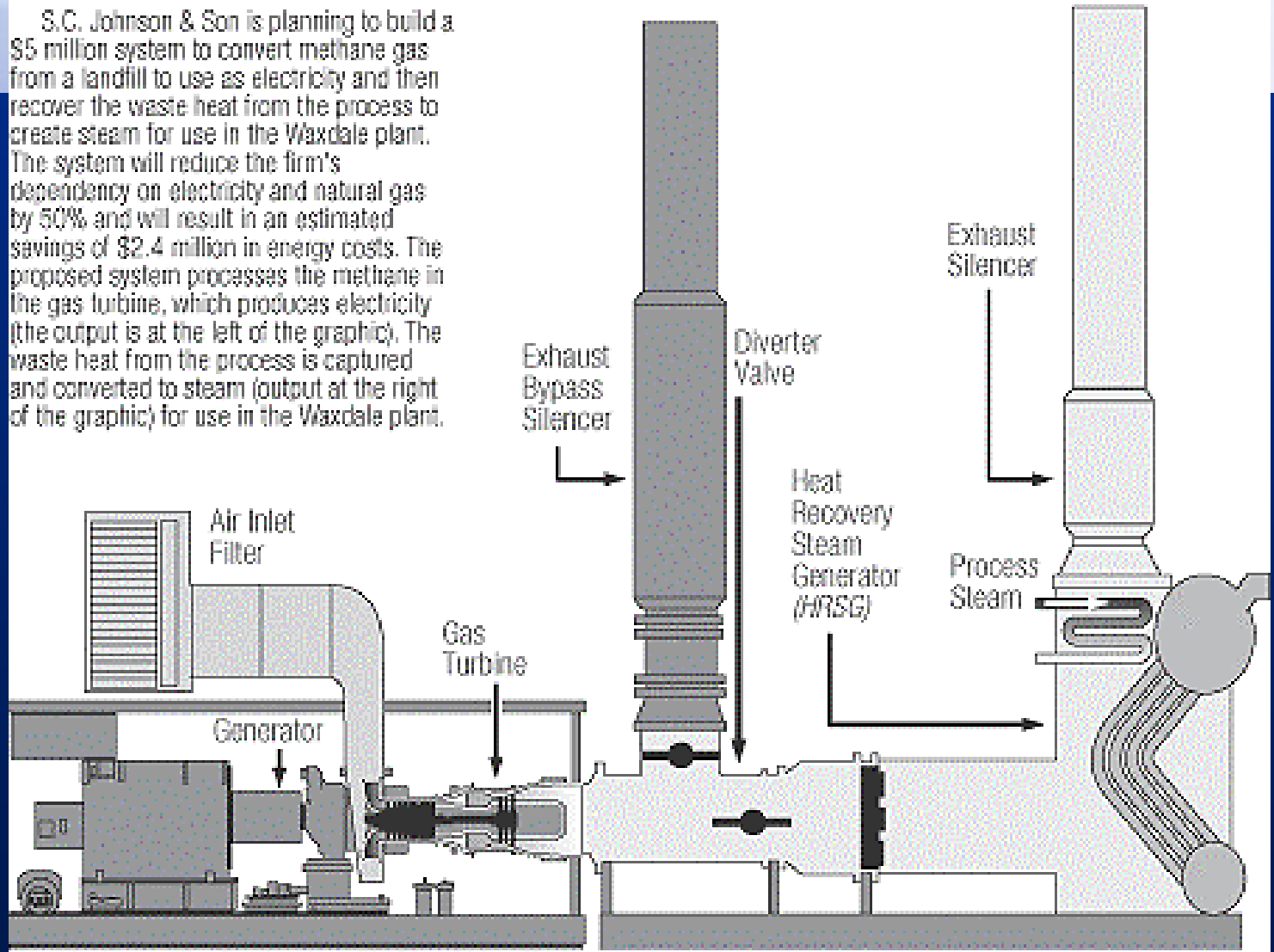
Combined Heat and Power

- **SC Johnson** (Racine, WI) - LFG replaces natural gas; will produce 3.2 MW of electricity using turbine and recover waste heat to produce 17,000 lb/hr steam; estimated net savings of $1 million/year.
- **BMW** (Greer, SC) - LFG replaces natural gas to fuel 4 1.25 MW turbines; waste heat used to produce hot water for thermal heating and industrial applications
- **Antioch High School** (IL) - 12-30 kW Capstone microturbines used to power and heat school

ENERGY

PLANT TO INSTALL COMBINED HEAT AND POWER SYSTEM

S.C. Johnson & Son is planning to build a $5 million system to convert methane gas from a landfill to use as electricity and then recover the waste heat from the process to create steam for use in the Waxdale plant. The system will reduce the firm's dependency on electricity and natural gas by 50% and will result in an estimated savings of $2.4 million in energy costs. The proposed system processes the methane in the gas turbine, which produces electricity (the output is at the left of the graphic). The waste heat from the process is captured and converted to steam (output at the right of the graphic) for use in the Waxdale plant.



Source: SC Johnson Co.

BOB VEIERSTAHLER/rveierstahler@jsonline.com

LANDFILL METHANE OUTREACH PROGRAM

Antioch Project

Electricity Generation

- Most prevalent in the US
  - In US, 1000 MW of capacity from over 200 operational projects
- Electricity sold to utility or nearby customer
- Average project size: 4 MWs

  Range: 30 kW - 50 MW
- Technologies
  - Internal Combustion (IC) Engine: 1-3 MW
  - Gas Turbine: 3-10 MW (new 1.7 MW)
  - Microturbines: 30 kW-200 kW
  - Others

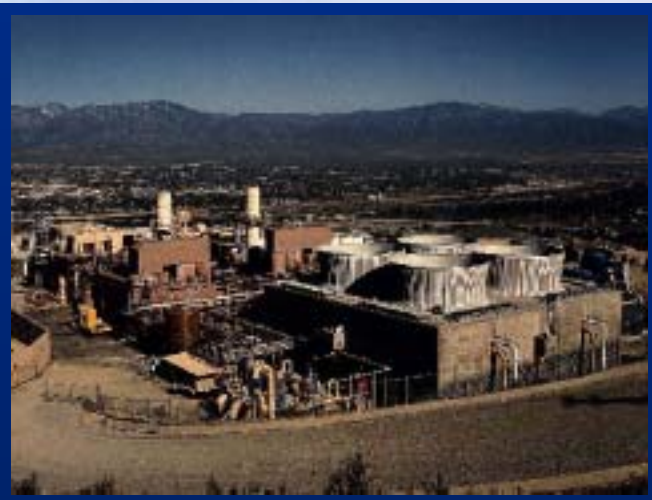
Internal Combustion Engine

- Sizing
  - 1-3 MWs
- Advantages
  - Low cost
  - High efficiency and reliability
  - Most common technology
- Disadvantages
  - Problems due to particulate matter buildup
  - Corrosion of engine parts and catalysts
  - High NOx emissions
- Costs
  - $1,100-1,300 ($/kW)
- Major suppliers - Cat, Jenbacher, Waukesha, Deutz

Turbines: Gas, Steam, and Combined Cycle

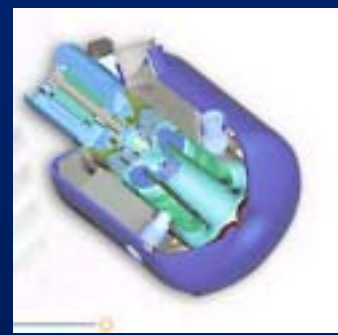
LANDFILL METHANE OUTREACH PROGRAM

- Sizing
  - 3-10MWs (new 1.7)
- Advantages
  - Corrosion resistant
  - Low O&M costs
  - Small physical size
  - Lower NOx emissions
- Disadvantages
  - Inefficient at partial load
  - High parasitic loads, due to high gas compression requirements
- Costs
  - $1,200-1,700 ($/kW)
- Major suppliers: Cat, Rolls Royce, Fairbanks-Morse



Microturbines

- Sizing
  - 30-200 kW
- Advantages
  - Low emissions
  - Multiple fuel capability
  - Light weight/small size
  - Lower maintenance costs
- Disadvantages
  - Low efficiencies
  - Extra treatment needed
  - Limited track record of performance
- Costs
  - $1,200-2,000 ($/kW)
- Major Suppliers: Ingersoll-Rand; Capstone



Jamacha (CA) Landfill

- Four 70 kW Ingersoll-Rand (IR) microturbines
- Methane content to 35%
- 10% of power for on site needs; rest to the grid
- Equipment:
  - 200 scfm blower/refrigeration skid
  - Switchgear and step up transformer
  - Remote monitoring and operation

Oll Landfill (CA)

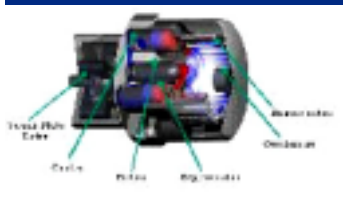
- Six 70 kW IR microturbines
- Serves on-site power needs for leachate treatment and flare station
- Equipment:
  - 300 scfm blower/refrigeration skid
  - Consolidation of three electric loads to single point
  - Switchgear, remote control

Eastern Regional Landfill (CA)

- Two 70 kW IR microturbines
- Power for flare station and transfer station
- Reduces county purchases, and generates revenue when power sold to the grid
- Equipment:
  - 95 scfm blower/refrigeration skid
  - 1,000-ft. compressed gas transmission line to transfer station
  - Switchgear; remote control

Emerging Technologies

- Fuel Cells
  - **Advantages**
    - **Low emissions; reduction in use of fossil fuels**
  - **Disadvantages**
    - **High cost; limited track record of performance**
  - **Costs**
    - **More expensive than traditional technologies**
    - **200 kW demonstration unit at California landfill = $1.5 million**
    - **Not enough data for cost range**



Stirling Cycle "External Combustion" Engine

Fuel Cell

Organic Rankine Cycle Engine

Palmdale (CA) WWTP Fuel Cell Project

- 250 kW FuelCell Energy, Inc. fuel cell. The fuel cell will use digester gas as a fuel. Methane content: 62%. The project will begin operation in February 2004.
- The project incorporates a digester gas pressurization & treatment skid and a waste heat hot water generator. The skid removes moisture, particulates, hydrogen sulfide, halogenated compounds and siloxanes. The hot water is used to heat the WWTP's anaerobic digesters, which frees up additional digester gas for power generation.
- The power plant will operate in parallel with Southern California Edison (SCE) as a baseload unit. The power plant displaces power otherwise bought from SCE at retail rates.

Alternate Fuels

- High-Btu Upgrade
  - Seven operational projects
  - Expensive and on-going technical issues
  - Need high volume of gas
- Medium-Btu Injection
  - One project on line (OH); others being explored
- LNG/CNG
  - One operational CNG project (CA); one LNG project under construction (PA)
- Methanol
  - Two projects in the planning stages

There Are Still Many Untapped LFG Resources

- Currently over 600 candidate landfills and a total MW potential of over 1,700 MW.
- Total expected annual environmental benefits if all projects were developed/ producing power:
  - **Planting over 20 million acres of forest, or**
  - **Removing the emissions from over 14.6 million cars on the road, or**
  - **Powering over 1 million homes per year.**

USVI Landfill Gas Energy Opportunities

- Information to be handed out on-site

LMOP Partner Tools and Services

- Feasibility Studies
- End User Searches
- Partnerships and networking
- Newsletter and listserv
- Direct Project Assistance
  - Feasibility studies, end user searches
- Technical Assistance Resource
- LFG Advocate
- PR/Ribbon Cuttings

NASA Administrator O'Keefe and former EPA Administrtor Whitman at NASA Project Opening.

LMOP Partner Recruitment Tools and Services

- Database
- Green Pricing Accreditation Involvement
- State Workshops/Conferences
  - working with state partner and SWANA
- Peer Matching
- Web Site (e.g., publications, database)

7th Annual LMOP Conference and 2003 LMOP Partner Awards

January 6-7, 2004 - Washington, DC

For More Information

- www.epa.gov/lmop - LMOP Hotline: 888-782-7937
- Chris Voell, voell.christopher@epa.gov, 202-343-9406